UV Digital Cameras Based on 32x32 and 128x128 Arrays of AlGaN p-i-n Photodiodes

J.D. Brown, J. Matthews, J. Boney, P. Srinivasan, J.F. SCHETZINA
North Carolina State University
Department of Physics - Box 8202
Raleigh, North Carolina 27695-8202, USA.
e-mail: jan_schetzina@ncsu.edu

Thomas Nohava, Wei Yang, Subash Krishnankutty
Honeywell Technology Center
12001 State Highway
Plymouth, Minnesota 55441, USA.

Visible-blind UV digital cameras based on 32x32 [1] and 128x128 arrays of AlGaN p-i-n photodiodes have been successfully developed. The nitride photodiode structures were synthesized on 2-inch diameter sapphire substrates polished on both sides in a low-pressure MOVPE system that employs vertical gas flows and fast substrate rotation. Two types of diode structures were prepared. The first type consists of a 1.5 μm thick n-type layer of $Al_{0.2}Ga_{0.8}N$:Si grown by MOVPE onto a low temperature AlN buffer layer on sapphire. On top of this layer is a 0.2 μm undoped GaN active layer followed by a 0.5 μm p-type GaN:Mg layer. This structure produces devices that respond to UV radiation in the 320-365 nm wavelength region when illuminated through-the-substrate. Selected test diodes displayed 300K peak responsivities as large as R = 0.21 A/W at 360 nm, corresponding to an internal quantum efficiency of 82%. Detectivities as large as $D^* = 6.1 \times 10^{13}$ cm $Hz^{1/2}$ W^{-1} were measured at 360 nm. This is one of the largest D* values ever obtained for any semiconductor photodetector at any wavelength and temperature, and is within a factor of six of D* values for UV-enhanced photomultiplier tubes. The second type of diode structure studied employs a base n-type layer of $Al_{0.35}Ga_{0.65}N$:Si onto which undoped and p-type layers of $Al_{0.2}Ga_{0.8}N$ are deposited sequentially by MOVPE. These devices respond to UV radiation in the 280-320 nm wavelength region. Selected test diodes of this type exhibit peak responsivities R = 0.14 A/W at 300 nm, corresponding to internal quantum efficiencies of 66%, and detectivities as large as $D^* = 1.2 \times 10^{13}$ cm $Hz^{1/2}$ W^{-1}

32x32 and 128x128 diode arrays were hybridized to Si readout integrated circuits (ROICs) using flip-chip bonding techniques in which In bump bonds were employed. The hybridized focal plane arrays (FPAs) were then wire-bonded to leadless chip carriers (LCCs) and inserted into the UV camera for testing. The UV digital camera employs an adjustable fused quartz lens for focusing the desired UV scene onto the AlGaN FPA, together with readout and testing electronics controlled by computer. The nitride FPA image can be read out from the Si ROIC and displayed real-time at frame rates ranging from 15-240 frames per second, or a sequence of images can be stored by computer as a digital image data set from which a selected frame or sequence of frames can be used to generate digital UV images or movies. A variety of UV imagery in the 280-365 nm region has been obtained using the nitride UV camera. Single-frame visible-blind UV images of alpha-numeric scenes and geometric objects have been obtained and will be displayed at the workshop. In addition, digital UV movies of pulsed xenon lamps, UV welding, and flame imagery will be presented. This work was supported by grants from DARPA and ARO.

[1] J.D. Brown et al., MRS Internet J. Nitride Semicond. Res. **4**, 9(1999).

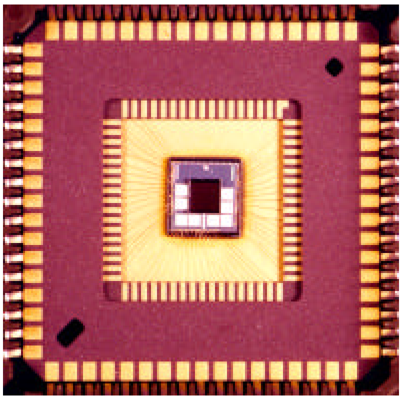

Figure 1. 32x32 UV FPA.

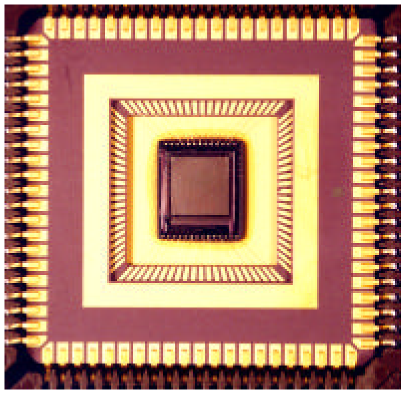

Figure 2. 128x128 UV FPA

Figure 3. NCSU UV camera.

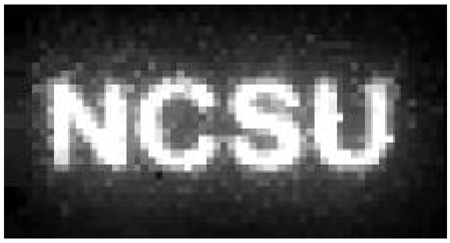

Figure 4. "NCSU" image from 128x128 FPA.

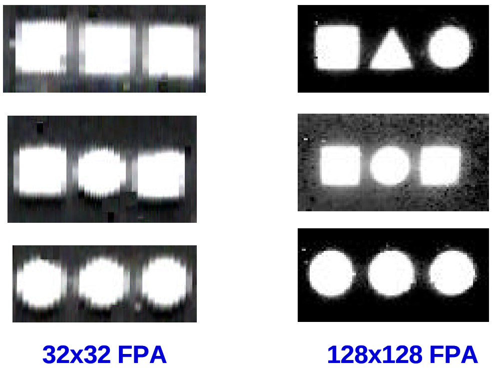

Figure 5. Outputs from 32x32 and 128x128 FPAs.

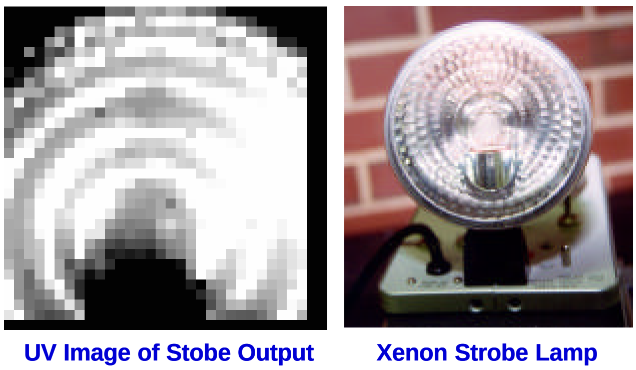

Figure 6. UV imagery of xenon strobe light.

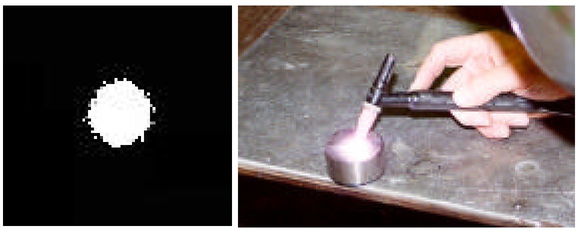

Figure 7. UV imagery of welding torch.

Figure 8. UV imagery of oxy-acetylene torch.